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CATALYTIC IGNITION AS A TOOL FOR CONVERTING SMALL ENGINES TO EFFICIENT JP-8 OPERATION

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SUMMARY/OVERVIEW:

Catalytic ignition permits small engines to operate efficiently with heavy fuels. The technology advances the Army towards its goal of a 'one-fuel' military and can improve the performance of heavy fuel engines operating under part-load conditions. Findings discussed below include: 1) selection of a 1-kW genset for catalytic ignition conversion after consultation with Army CECOM; 2) conversion of a 5-kW genset from gasoline to jet fuel operation at rated power using Smart Plug® catalytic igniters; and 3) design changes to improve Smart Plug® durability.

TECHNICAL DISCUSSION

Work began on this project during the summer of 2000. Key issues that were addressed were selection of small engine test platforms, conversion of a 5 kW gasoline genset to catalytic ignition of aviation fuel, continued development of a reactor for detailed mechanism studies, changing catalytic igniter design features for JP 8 operation, expanding engine testing infrastructure, and development of local emissions testing infrastructure to compensate for laboratory facilities at Idaho National Engineering and Environmental Laboratory (INEEL) that are no longer available.

Portable Genset Platform

Personnel at CECOM in the Army's power generation branch explained the Army's problems with mobile power generation during our visit to Ft. Belvoir in October. These problems, and our approach to create solutions, are summarized below.

Although the Army's 2-kW gensets use L-40 or L-48 Yanmar diesel engines successfully with JP-8 or diesel, the gensets have problems with engine longevity at light loads. Carbon

buildup from wet stacking has killed lightly loaded gensets in the field. The current idea for control is to apply a 750 W heater to the engine, or to apply a dummy load. These gensets weigh ~140 lbs. and are expensive at $5k each.

The radical pool generated by the catalyst may help obtain complete combustion to prevent C buildup, as well as permit easier cold start.

The Army's diesel 5-kW gensets (800 pounds) also exhibit performance degradation with extended operation at low loads.

While the Army has a work-around planned for the 2-kW genset (externally heating the engine or creating a dummy load), one reason for the light loading problems is the need for 500 W to 1 kW gensets. The Army currently has no gensets with this power output that operate on diesel or JP-8. Commercially available gensets in this size range – for example, Honda models 1800 and 2000 – meet the weight requirement (these gensets weigh less than 20 lbs) but run on gasoline.

Conversion of a small genset, like the Honda, to operation with heavy fuels (D1, D2, JP-5 and/or JP-8) would meet a need the military has today. The Army does not need a large number of gensets each year; finding a world market for small multi-fuel gensets is key for a manufacturer to make this product line successful – and even more promising if the genset could also operate on gasoline. The Army did not have problems with a contractor purchasing an existing system and modifying it to meet its needs, especially since this could keep the price per unit down.

In addition to cold start, maintaining rated power at altitude and high temperature, the Army wants a fast response system - one that will go from idle to full power without stall. Ergonomic considerations - convenience of use, lightweight, quiet operation - must be addressed. Efficiency, power output and durability are also important.

Consequently, in the scope of this project we intend to investigate:

- Conversion of a small genset to heavy fuel operation, followed by
- Optimizing operation of a 2 kW genset with heavy fuel.

After an igniter is designed and the electrical system modified for a small genset, a series of tests are needed. We plan to:

- Perform endurance testing following the Engine Manufacturer's Association (EMA) guidelines
- Devise a new test for prolonged operation at idle or 10% load
- Develop small engine cold start test capabilities (-30°F)
- Perform power rating tests either at simulated altitude testing and elevated temperature (140°F) (e.g. using an Army facility) or devise a self-contained trailer that we can pull to 8,000 feet in Idaho
- Conduct sound tests using a portable sound sensor

- Perform emissions measurements
- Monitor engine wear and catalyst erosion

Finally, other applications of the igniter technology are possible, for example, rotary engine genset/pumpsets, power units for the AAAV (Advanced Amphibian Assault Vehicle), or auxiliary power units for hybrid electric vehicles. Lessons learned in this project can be applied to other small engines throughout the military.

Conversion of a 5 kW Gasoline Genset to Jet Fuel Operation

An Army 5-kW gasoline-fueled genset with a Wisconsin engine was converted to jet fuel operation with catalytic ignition. The converted genset ran at rated power. The conversion require replacing the spark plugs with Smart Plug® catalytic igniters and removing the high-tension coil and distributor system.

Igniter Development

Two significant design improvements to the Smart Plug® catalytic igniters have been made.

One of the main issues of igniter failure has been with the electrical heater that supplies heat to the catalyst during startup. The igniter would run fine while the engine was running, but once cooled down, if the heater wire was broken [Figure 1], it was not possible to start the engine again. The heater wiring has been changed so that the grounding side of the heater exits out of the bottom of the pre-chamber instead of wrapping it back up to the top – where it usually fails. This uses less of the expensive wire, and has proven to be more robust providing a longer igniter life.

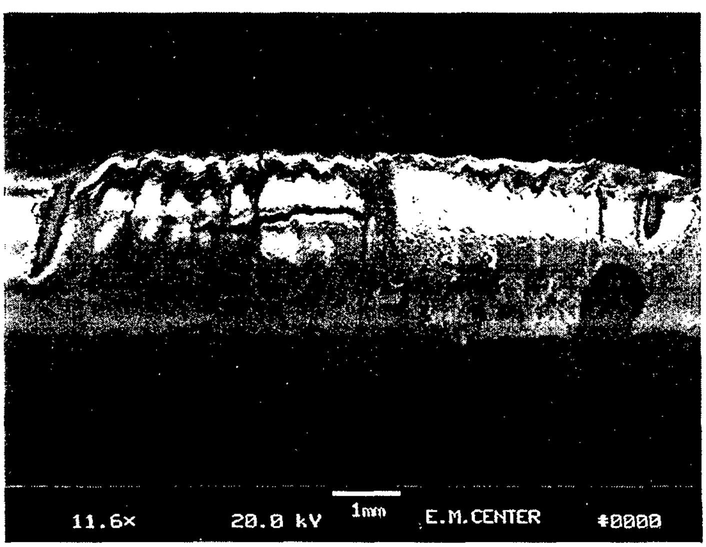

Figure 1. SEM photograph of catalytic igniter failure.

Another change was in the geometry of the igniter bodies. Previous Smart Plug® designs had used changes in the core length to produce changes in ignition timing. The new concept uses changes in pre-chamber diameter to vary the ignition timing. This provides an easier way to change timing that does not require making new cores, which are expensive. The cores can be manufactures more universally – thus dropping manufacturing costs. Only the igniter bodies need to be changed for each application.